ATOMIC ENERGY CENTRAL SCHOOL,ANUPURAM

CH-6 Work Power and Energy(module1/6)

Prepared By : Pooja Kumari
PGT PHYSICS,AECS ANUPURAM

INTRODUCTION

- The terms 'work', 'energy' and 'power' are frequently used in everyday language. A farmer clearing weeds in his field is said to be working hard. A woman carrying water from a well to her house is said to be working. In a drought affected region she may be required to carry it over large distances. If she can do so, she is said to have a large stamina or energy. Energy is thus the capacity to do work. The term power is usually associated with speed. In karate, a powerful punch is one delivered at great speed. In physics we shall define these terms very precisely. We shall find that there is at best a loose correlation between the physical definitions and the physiological pictures these terms generate in our minds. Work is said to be done when a force applied on the body displaces the body through a certain distance in the direction of force.
- Work done When a force acts on an object and the object actually moves in the direction of force, then the work is said to be done by the force. Work done by the force is equal to the product of the force and the displacement of the object in the direction of force.

  If under a constant force F the object displaced through a distance s, then work done by the force

  $W = F * s = F s \cos\theta$, where θ is the smaller angle between F and s.

  Work is a scalar quantity, Its S1 unit is joule and CGS unit is erg.

∴ 1 joule = 107 erg

- Its dimensional formula is $[ML^2T^{-2}]$.
- Work done by a force is zero, if

  (a) body is not displaced actually, i.e., $s = 0$

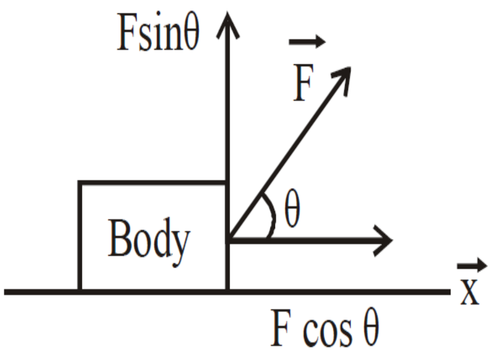
  (b) body is displaced perpendicular to the direction of force, i.e. $\theta = 90°$
- Work done by a force is positive if angle between F and s is acute angle.
- Work done by a force is negative if angle between F and s is obtuse angle.

WORK DONE BY A CONSTANT FORCE

Work done (W) by a force in displacing a body through a displacement x is given by

$W = F.x = Fx \cos \theta$

- Where θ is the angle between the applied force an



1 joule = 10^7 erg When $\theta = 0°$ then $W = Fx$

- When θ is between 0 and $\pi/2$ then

  $W = Fx \cos \theta$ = **positive**

- When $\theta = \pi/2$ then $W = Fx \cos 90° = 0$ **(zero)**

- Work done by centripetal force is zero as in this case angle $\theta = 90°$

  ∴ When θ is between $\pi/2$ and π then

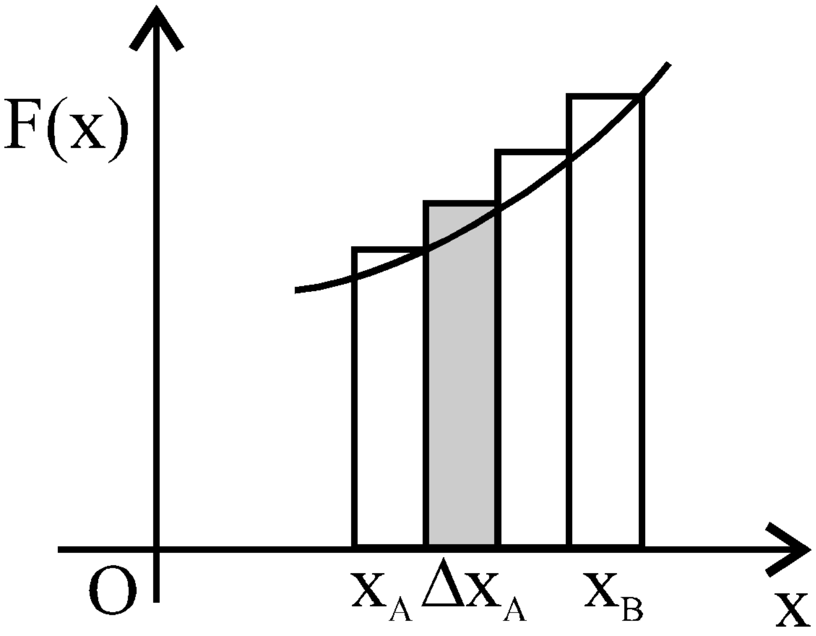
  $W = Fx \cos \theta$ = **negative**

Examples of work done

- **Positive work:** when force and displacement are in the same direction, the work performed on an object is said to be positive work.
- Example: When a body moves on the horizontal surface, force and displacement act in the forward path. The work is done in this case known as Positive work.
- **Negative work**: Negative work is performed if the displacement is opposite to the direction of the Force applied.
- Example: Work was done the gravity on a rocket going perpendicular upwards.
- **Zero work:** When force and displacement are perpendicular to each other, or when force or displacement is zero.
- Example: When we hold an object and walk, the force acts in a downward direction whereas displacement acts in the forward direction.

WORK DONE BY A VARIABLE FORCE

When the force is an arbitrary function of position, we need the techniques of calculus to evaluate the work done by it. The figure shows F_x as function of the position x. We begin by replacing the actual variation of the force by a series of small steps.

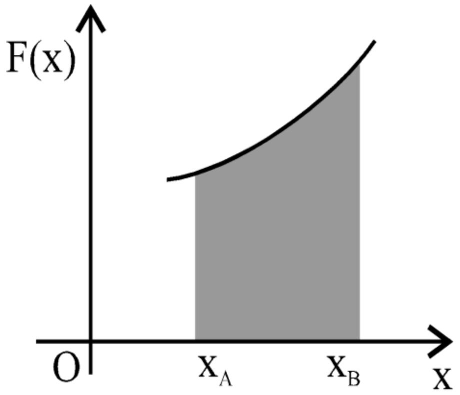


The area under each segment of the curve is approximately equal to the area of a rectangle.The height of the rectangle is a constant value of force, and its width is a small displacement Δx. Thus, the step involves an amount of work $\Delta W_n = F_n \, \Delta x_n$. The total work done is approximately given by the sum of the areas of the rectangles.

i.e., $W \approx \Delta x_n$.

As the size of the steps is reduced, the tops of the rectangle more closely trace the actual curve shown in figure. If the limit Δx → 0, which is equivalent to letting the number of steps tend to infinity, the discrete sum is replaced by a continuous integral.

$$W = \lim_{\Delta x_n \to 0} \sum F_n \Delta x_n = \int F_x dx$$



Thus, the work done by a force F_x from an initial point A to final point B is

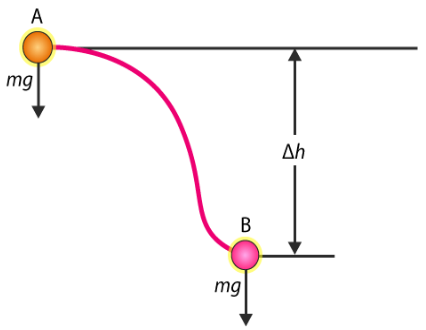
$$W_{A \to B} = \int_{x_A}^{x_n} F_x dx$$

The work done by a variable force in displacing a particle from x_1 to x_2

$$W = \int_{x_1}^{x_2} F dx$$

What is Conservative Force?

- As the name suggests, conservative force conserves energy. It follows the law of conservation of energy. Many forces in nature that we know of like the magnetic force, electrostatic force, gravitational force, etc. are a few **examples of a conservative force**. Let us understand the concept better with the help of the following example.



Gravitational force acting on a particle

In the given image, the gravitational force acting on the particle has a magnitude equal to *mg*, where *m* is the mass of the substance and *g* is the acceleration due to gravity. The particle moves from point *A* to point *B*, and its vertical displacement is given by Δh. The pink curve in the image represents the arbitrary path travelled by the body due to the influence of other forces acting on the body. But the arbitrary path is of no consideration to the force of gravity as it is unaffected by them and therefore can be treated independently. The force of gravity is only dependent on the vertical displacement.

The total work done by gravity on the body is given as follows:

$W_g = -mg\,(\Delta h)$

Where, *Δh* is the difference between the final position (at point *B*) and the initial position (at point *A*)

g is the acceleration due to gravity

m is the mass of the body

No matter how complicated the path taken by the particle might be, we can easily find out the work done by gravity on the particle using the above expression just by knowing the vertical displacement. From this, we can conclude that the gravitational force doesn’t depend on the path taken but only depends on the initial and final position. Hence, the gravitational force is a conservative force.

What is Non-Conservative force?

- A non-conservative force is a force for which the work done depends on the path taken. Friction is an example of a non-conservative force. A force is said to be a non-conservative force if it results in the change of mechanical energy, which is nothing but the sum of potential and kinetic energy. The work done by a non-conservative force adds or removes mechanical energy. For example, when work is done by friction, thermal energy is dissipated. The energy lost cannot be fully recovered.

Properties of Non-Conservative Forces

It has the opposite properties of conservative forces. The properties are given below:

It is path dependent therefore it also depends on the initial and final velocity.

In any closed path, the total work done by a non-conservative force is not zero. The work done by a non-conservative is irreversible.

Power

- **Definition:** Power can be defined as the rate at which work is done i.e. energy converted.
- **Formula :**The formula for power is
- $P = W/t$
- **Unit:** The unit of power is watt (W).
- The Dimensional Formula of Power
- Dimensional Formula for Power is given by
- $[M^1L^2T^{-3}]$

Energy

Definition: In physics, we can define energy as the capacity to do work.

Formula For the potential energy the formula is $P.E. = mgh$

Unit : The SI unit of energy is joules (J), which is named in honour of James Prescott Joule.

What is Energy?

- Energy is the ability to perform work. Energy can neither be created nor destroyed. It can only be transformed from one kind to another. The unit of Energy is same as of Work i.e. Joules. Energy is found in many things and thus there are different types of energy.
- All forms of energy are either kinetic or potential. The energy in motion is known as Kinetic Energy whereas Potential Energy is the energy stored in an object and is measured by the amount of work done.

Types of Energy

Some other types of energy are given below:

- Mechanical energy
- Mechanical wave energy
- Chemical energy
- Electric energy
- Magnetic energy
- Radiant energy
- Nuclear energy
- Ionization energy
- Elastic energy
- Gravitational energy
- Thermal energy
- Heat Energy